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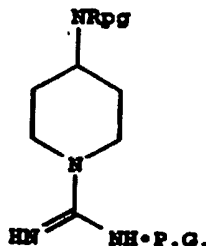
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(54) Process for preparing intermediates for thrombin inhibitors

(57) A process is provided for preparing intermediates of the structure



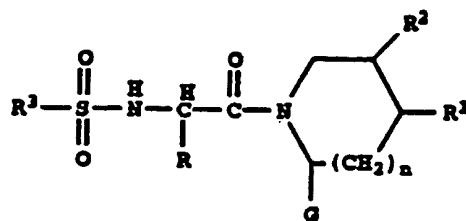
wherein Rpg is preferably =CHC<sub>6</sub>H<sub>5</sub>; and P.G. is a protecting group CBZ or BOC, wherein a protected guan-  
ylpyrazole is reacted with an azacycloalkyl, azacyclo-  
alkenyl or azaheteroalkyl derivative (such as a piperid-  
ine derivative) in the presence of a DBU catalyst. The  
resulting intermediate may be used as a starting mate-  
rial for preparing thrombin inhibitors.

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## Description

The present invention relates to a substituted guanidine intermediate which is useful for preparing thrombin inhibitors, and to a process for preparing such an intermediate.

U.S. application Serial No. 146,714 filed November 10, 1993 (EP-A-601459) (incorporated herein by reference) discloses thrombin inhibitors of the structure



including all stereoisomers, wherein n is 0, 1 or 2;

G is an amido moiety which includes a cyclic member;

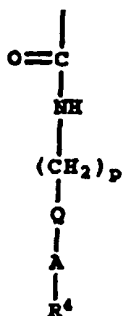
R is hydrogen, hydroxyalkyl, aminoalkyl, alkyl, cycloalkyl, arylalkyl, alkenyl, alkynyl, amidoalkyl, arylalkoxyalkyl or an amino acid side chain, either protected or unprotected;

R¹ and R² are independently hydrogen, lower alkyl, cycloalkyl, aryl, hydroxy, alkoxy, keto, thioketal, thioalkyl, thioaryl, amino or alkylamino; or R¹ and R² together with the carbons to which they are attached form a cycloalkyl, aryl or heteroaryl ring;

R³ is alkyl, arylalkyl, aryl, heteroaryl, quinolinyl or tetrahydroquinolinyl;

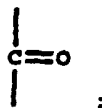
including pharmaceutically acceptable salts thereof, and

G is

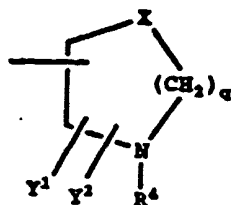


wherein p is 0, 1 or 2;

Q is a single bond or



A is aryl or cycloalkyl or an azacycloalkyl ring of 4 to 8 members or an azaheterocycloalkyl ring of 6 to 8 members of the structure



where X is CH<sub>2</sub>, O, S or NH;

q is 0, 1, 2, 3 or 4, provided that

q is 0, 1, 2, 3 or 4 if X is CH<sub>2</sub>;

q is 2, 3 or 4 if X is O, S or NH;

Y<sup>1</sup> and Y<sup>2</sup> are independently H, lower alkyl, halo or keto;

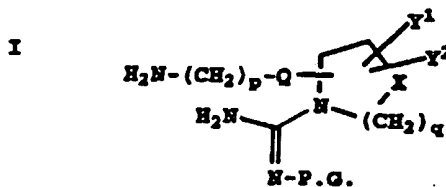
R<sup>4</sup> is guanidino, amidino or aminomethyl; with the provisos that where A is aryl or cycloalkyl, R<sup>4</sup> is guanidino, amidino or aminomethyl,

where A is azacycloalkyl or azaheterocycloalkyl, R<sup>4</sup> is amidino;

where A is azaheterocycloalkyl, then there must be at least a 2-carbon chain between X and any N atom in the ring or outside the ring.

### Description of the Invention

In accordance with the present invention, a process is provided for preparing a guanidine intermediate of the structure



wherein p is 0, 1 or 2;



Q is a single bond or

Y<sup>1</sup> and Y<sup>2</sup> are independently H, lower alkyl or halo;

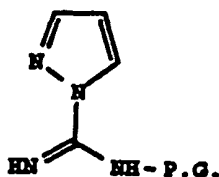
X is CH<sub>2</sub>, -CH=CH-, O, S or NH;

q is 0, 1, 2, 3 or 4 if X is CH<sub>2</sub> or -CH=CH-;

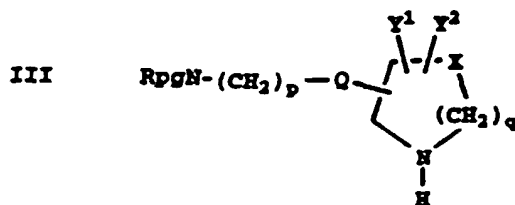
q is 2, 3 or 4 if X is O, S or NH;

and P.G. is an amine protecting group which preferably is benzyloxycarbonyl (CBZ) or t-butoxycarbonyl (BOC), and the N-, X-containing ring is referred to as azacycloalkyl, azacycloalkenyl, azaheterocycloalkyl or the A ring, which process includes the steps of providing a protected guanylpurazole of the structure

II

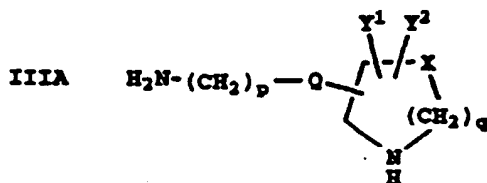


where P.G. is as defined above, and reacting the protected guanylpurazole II with a compound of the structure



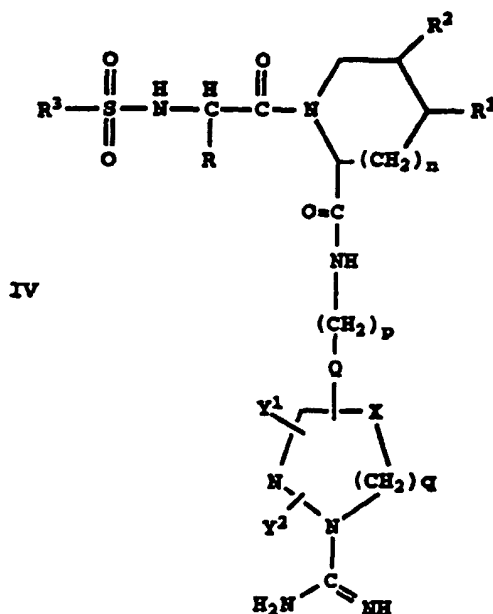
where p, Q, X, q and Y<sup>1</sup> and Y<sup>2</sup> are as defined above and Rpg is an N-protecting group, for example, a Schiff base such as =CHC<sub>6</sub>H<sub>5</sub>, CBZ, or BOC in the presence of a basic catalyst, such as triethyl-amine, or diisopropylethyl-amine, and preferably 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) or 1,5-diazabicyclo[4.3.0]non-5-ene (DBN), to form the guanidine intermediate I.

Starting material III may be prepared by reacting the corresponding unprotected amino compound IIIA



with an aldehyde such as benzaldehyde at a temperature within the range from about 25 to about 120°C.

In addition, in accordance with the present invention, a process is provided for employing the (e.g. substituted piperidinoguanidine)intermediate I for preparing sulfonamido heterocyclic thrombin inhibitors of the structure



R is hydrogen, hydroxyalkyl, aminoalkyl, amidoalkyl, alkyl, cycloalkyl, aryl, arylalkyl, alkenyl, alkynyl, arylalkoxy-alkyl, or an amino acid side chain, either protected or unprotected;

R<sup>1</sup> and R<sup>2</sup> are independently hydrogen, lower alkyl, cycloalkyl, aryl, hydroxy, alkoxy, oxo (also referred to as keto),

thioxo, thioketal, thioalkyl, thioaryl, amino or alkylamino; or  $R^1$  and  $R^2$  together with the carbons to which they are attached form a cycloalkyl, aryl, or heteroaryl ring; and

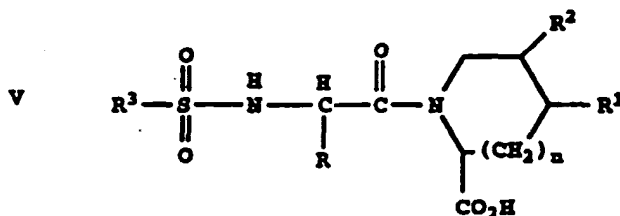
$R^3$  is lower alkyl, aryl, arylalkyl, heteroaryl, quinolinyl or tetrahydroquinolinyl;

$n$  is 0, 1 or 2;

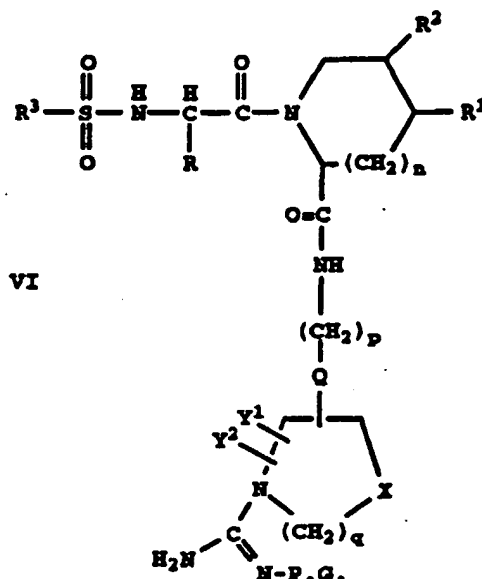
and  $p$ ,  $Q$ ,  $X$ ,  $q$ ,  $Y^1$  and  $Y^2$  are as defined hereinbefore.;

provided that where  $X$  is a hetero atom (that is, a ring is azaheterocycloalkyl), then there must be at least a 2-carbon chain between  $X$  and any N atom in the ring outside the ring  $A$ ;

which process includes the steps of providing the intermediate I, reacting the intermediate I with an acid of the structure V



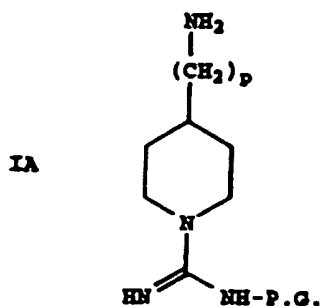
in a carbodiimide coupling reaction, in the presence of a coupling agent such as ethyl 3-(3-dimethylamino)propyl carbodiimide hydrochloride (WSC) or dicyclohexyl-carbodiimide (DCC) or diisopropylcarbodiimide (DIC), and 1-hydroxybenzotriazole monohydrate (HOBT), and optionally in the presence of a suitable base such as N-methylmorpholine (NMM) or triethylamine, and in the presence of a solvent such as aqueous isopropanol, dimethylformamide (DMF), THF, dichloromethane, or N-methylpyrrolidone, to form the protected compound VI



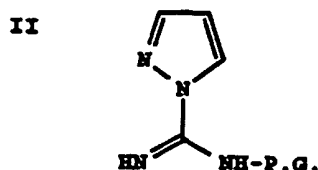
and removing the protecting group, by standard deprotection procedures, for example, by hydrogenation where P.G. is CBZ, or by treatment with trifluoroacetic acid or anhydrous HCl where P.G. is BOC, to form the guanidine thrombin inhibitor IV.

Thus, through use of the substituted piperidinoguanidine intermediates I, prepared in accordance with the process of the invention, thrombin inhibitors IV as essentially disclosed in EP-A-601459 mentioned above may be prepared.

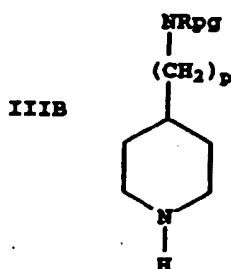
In accordance with the present invention, a preferred process is provided for preparing an intermediate of the structure



15 wherein P.G. is an amine protecting group such as benzyloxycarbonyl (CBZ) or t-butoxycarbonyl (BOC), which process includes the steps of providing a protected guanylpiprazole of the structure II

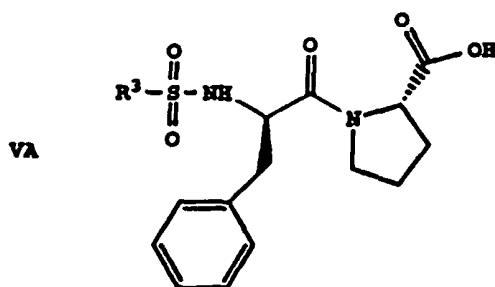


25 where P.G. is a protecting group as defined above, and reacting the protected guanylpiprazole II with a piperidine derivative of the structure IIIB



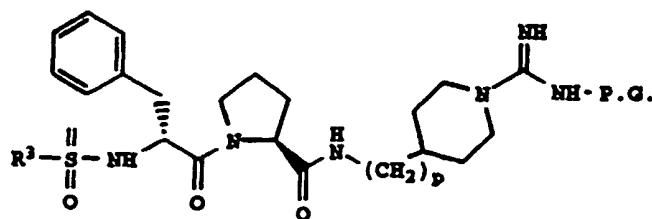
35 where Rpg is a protecting group such as CBZ, BOC or a Schiff base derivative, preferably =CHC<sub>6</sub>H<sub>5</sub>. However, it will be understood that the protecting group Rpg will always differ from the protecting group P.G. The reaction is carried out in the presence of a basic catalyst as defined above, and in an inert organic solvent such as DMF, or preferably acetonitrile. Thereafter, the protecting group Rpg is removed by conventional techniques to form the substituted piperidino-guanidine intermediate I.

40 In another aspect of the present invention, a preferred process is provided for employing the substituted piperidino-guanidine intermediate I to prepare a thrombin inhibitor IV. In the preferred embodiment of the invention, the substituted piperidinoguanidine intermediate IA is coupled with an acid compound of the structure VA



wherein  $R^3$  is preferably alkyl, aryl, or arylalkyl, more preferably methyl or benzyl, in a carbodiimide coupling reaction, as described hereinbefore, to form protected guanidine thrombin inhibitor of the structure VIA

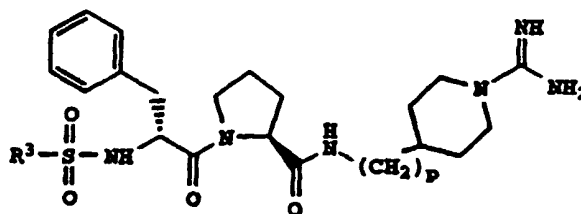
VIA



where  $R^3$  is preferably  $CH_3$  or benzyl.

Guanidine thrombin inhibitor VIA is deprotected, for example, where P.G. is CBZ, by hydrogenation to form guanidine thrombin inhibitor IVA

IVA



where  $R^3$  is preferably  $CH_3$  or benzyl.

The guanidine thrombin inhibitor VIA may be reacted with an organic acid, such as acetic acid or with a hydrohalic acid, such as HCl to form a pharmaceutically acceptable salt as described in detail hereinafter.

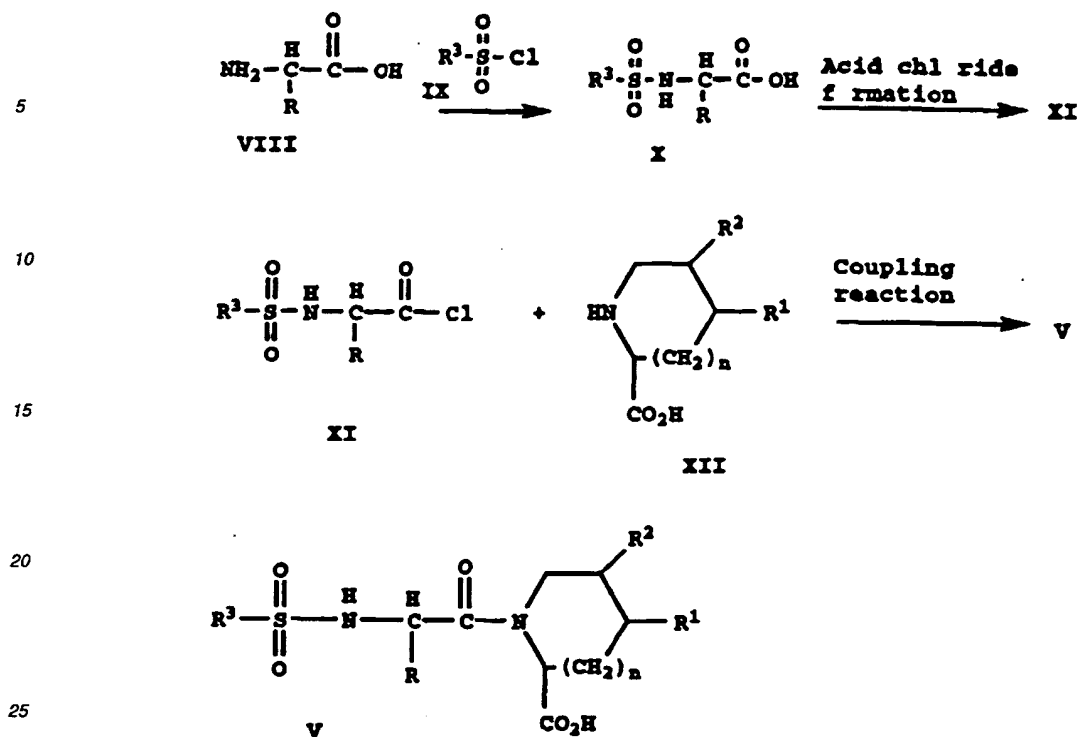
#### Detailed Description of the Invention

In carrying out the process of the invention, in forming intermediate I (or IA), the protected guanylpiprazole II will be employed in a molar ratio to III (or IIIB) within the range from about 1:1 to about 3:1, preferably from about 1.1:1 to about 2:1. The reaction of II and III (or IIIB) will be carried out at a temperature within the range from about 20 to about 70°C, preferably from about 40 to about 60°C, preferably under an inert atmosphere such as nitrogen or argon.

The basic catalyst employed in the reaction of II and III (or IIIB) will include DBU, DBN, triethylamine or diisopropylethylamine, preferably DBU or DBN, and will be employed in a molar ratio to III within the range from about 1:1 to about 3:1, preferably from about 1.1:1 to about 2:1.

In carrying out the process of the invention for forming thrombin inhibitor IV (or IVA), intermediate I (or IA) will be employed in a molar ratio to V (or VA) within the range from about 1.1:1 to about 3:1, preferably from about 1.1:1 to about 2:1, and the coupling reaction will be carried out at a temperature within the range from about 0 to about 30°C, preferably from about 5 to about 20°C.

The starting material V may be prepared as set out in the following reaction sequence.

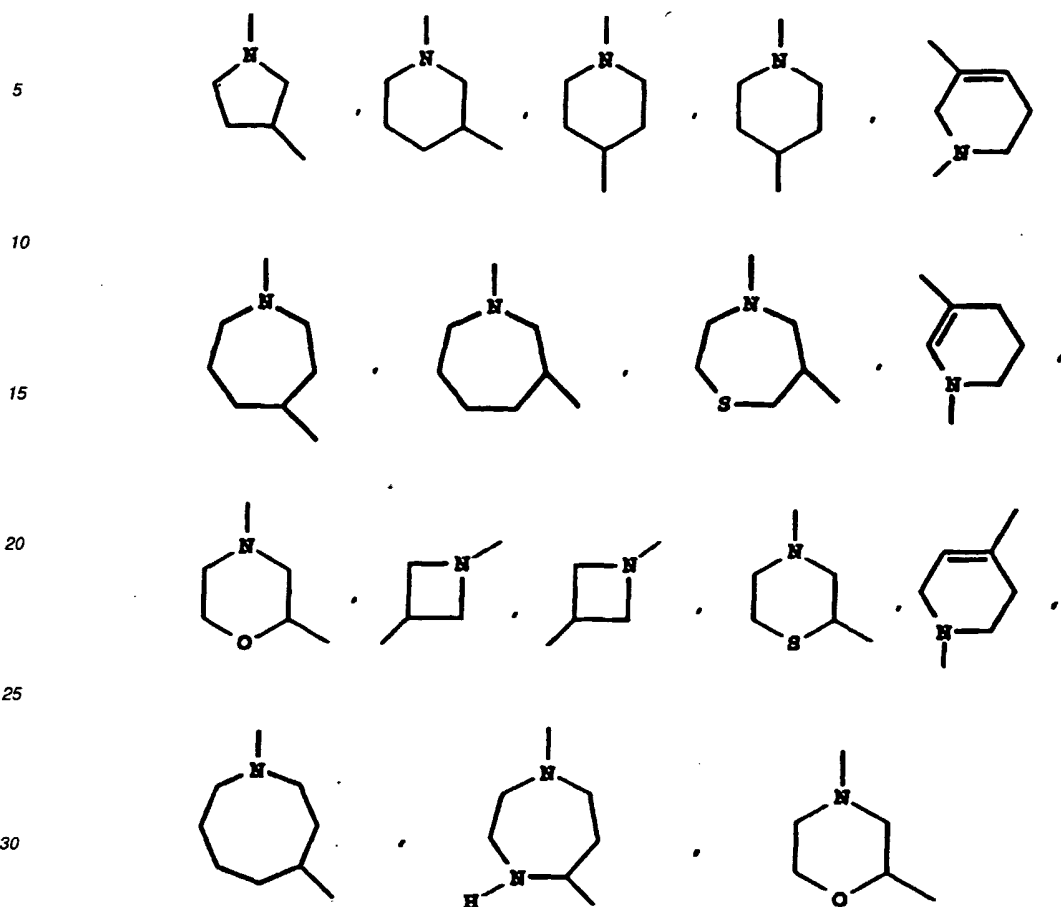


30 As seen in the above reaction sequence, compounds of formula V are prepared as follows.

Amino acid VIII is reacted with sulfonyl chloride IX in the presence of aqueous base such as NaOH, and optionally in the presence of an organic cosolvent, to form sulfonamide X. Sulfonamide X is subjected to acid chloride formation by treating X with oxalyl chloride or thionyl chloride in the presence of an inert organic solvent and catalytic amounts of DMF to form acid chloride XI. Acid chloride XI is coupled with acid XII in the presence of aqueous base, and optionally in the presence of an organic cosolvent, to form V.

Examples of the A ring (azacycloalkyl, azacycloalkenyl or azaheterocycloalkyl) which may be employed herein include





and the like.

Preferred are compounds wherein Q is a single bond and A is an azacycloalkyl ring



50 where q is 0 or 1; and  
 R<sup>3</sup> is lower alkyl or aryl;  
 R is aralkyl or hydroxyalkyl;  
 R<sup>1</sup> and R<sup>2</sup> are each H;  
 n is 0 or 1.

# In General

The term "lower alkyl" or "alkyl" as employed herein by itself or as part of another group includes both straight and

branched chain radicals of up to 18 carbons, preferably 1 to 8 carbons, such as methyl, ethyl, propyl, isopropyl, butyl, t-butyl, isobutyl, pentyl, hexyl, isohexyl, heptyl, 4,4-dimethylpentyl, octyl, 2,2,4-trimethylpentyl, nonyl, decyl, undecyl, dodecyl, the various branched chain isomers thereof, and the like as well as such groups including 1, 2 or 3 halo substituents (for example, to form  $\text{CF}_3$  or  $\text{CF}_3\text{CH}_2$ ) and/or 1 or 2 of the following substituents: an aryl substituent (for example, to form benzyl or phenethyl), an alkyl-aryl substituent, a haloaryl substituent, a cycloalkyl substituent, an alkylcycloalkyl substituent, an alkenyl substituent, an alkynyl substituent, hydroxy or a carboxy substituent. It will be appreciated that the same "alkyl" group may be substituted with one or more of any of the above substituents.

The term "cycloalkyl" by itself or as part of another group includes saturated cyclic hydrocarbon groups containing 3 to 12 carbons, preferably 3 to 8 carbons, which include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, cyclooctyl, cyclodecyl and cyclododecyl, any of which groups may be substituted with substituents such as halogen, lower alkyl, alkoxy, and/or hydroxy groups.

The term "aryl" or "Ar" as employed herein by itself or as part of another group refers to monocyclic or bicyclic aromatic groups containing from 6 to 10 carbons in the ring portion, such as phenyl, or naphthyl. Aryl (or Ar), phenyl or naphthyl may include substituted aryl, substituted phenyl or substituted naphthyl, which may include 1, 2, 3, 4 or 5 substituents on either the Ar, phenyl or naphthyl such as lower alkyl, cyano, amino, alkylamino, dialkylamino, nitro, carboxy, carboalkoxy, trifluoromethyl, halogen (Cl, Br, I or F), lower alkoxy, aryl-alkoxy, hydroxy, alkylthio, alkylsulfanyl, alkylsulfonyl, arylthio, arylsulfanyl and/or arylsulfonyl.

Thus, a phenyl group  $\text{R}^3$  may include 3, 4 or 5 substituents such as alkyl, for example, pentamethyl and 2,4,6-trisopropyl, and halo, for example, pentafluoro.

The term "aralkyl", "aryl-alkyl" or "aryl-lower alkyl" as used herein by itself or as part of another group refers to lower alkyl groups as discussed above having an aryl substituent, such as benzyl.

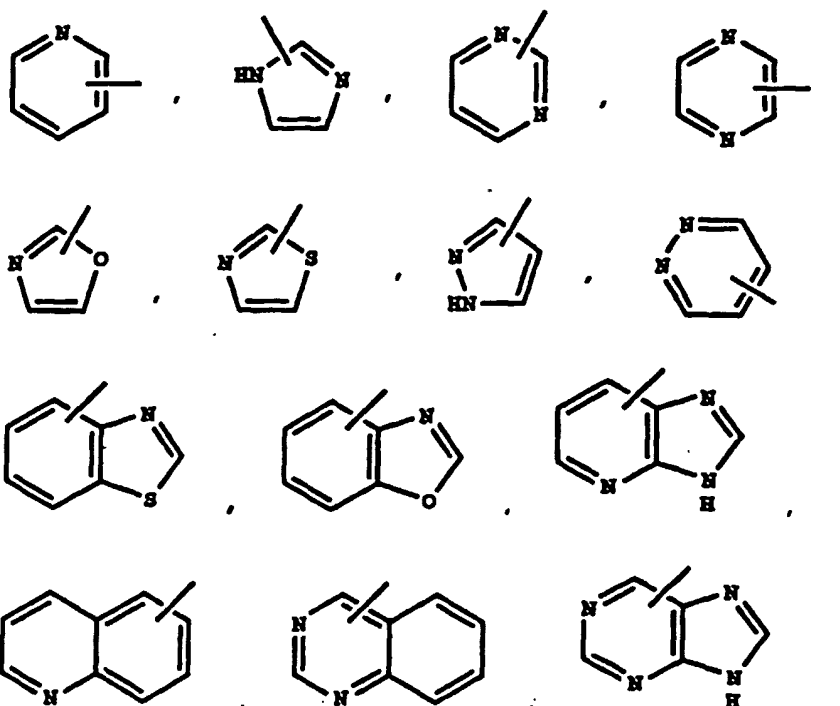
The term "lower alkoxy", "alkoxy" or "aralkoxy" includes any of the above lower alkyl, alkyl or aralkyl groups linked to an oxygen atom.

The term "halogen" or "halo" as used herein by itself or as part of another group refers to chlorine, bromine, fluorine or iodine with chlorine being preferred.

The term "lower alkenyl" or "alkenyl" as employed herein by itself or as part of another group includes a carbon chain of up to 16 carbons, preferably 3 to 10 carbons, containing one double bond which will be separated from "N" by at least one saturated carbon moiety such as  $-(\text{CH}_2)_{q'}-$  where  $q'$  can be 1 to 14, such as 2-propenyl, 2-butenyl, 3-butenyl, 2-pentenyl, 4-pentenyl and the like, and may include a halogen substituent such as I, Cl, or F.

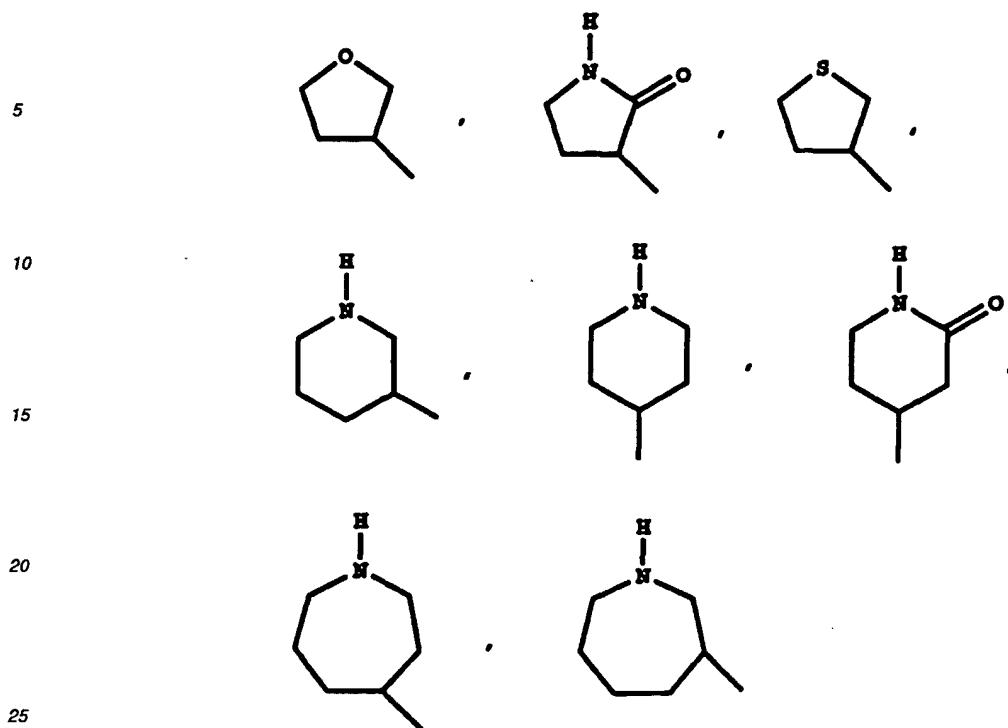
The term "lower alkynyl" or "alkynyl" as employed herein by itself or as part of another group includes a carbon chain of up to 16 carbons, preferably 3 to 10 carbons, containing one triple bond which will be separated from "N" by at least one saturated carbon moiety such as  $-(\text{CH}_2)_{q'}-$  where  $q'$  can be 1 to 14, such as 2-propynyl, 2-butyryl, 3-butyryl and the like.

The term "heteroaryl" or heteroaromatic by itself or as part of another group refers to a 5- to 10-membered aromatic ring(s) which includes 1, 2, 3 or 4 hetero atoms such as nitrogen, oxygen or sulfur, such as



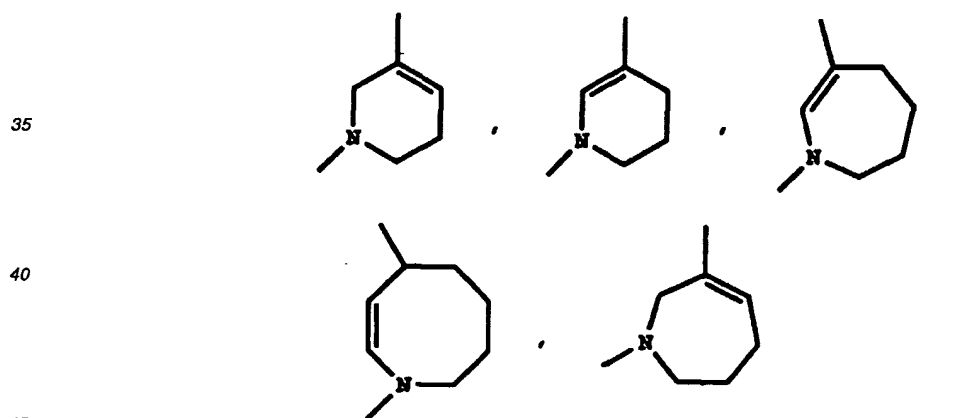
and the like. The heteroaryl rings may optionally be fused to aryl rings defined previously. The heteroaryl rings may optionally include 1 or 2 substituents such as halogen (Cl, Br, F or CF<sub>3</sub>), lower alkyl, lower alkoxy, carboxy, amino, lower alkylamino and/or dilower alkylamino.

The term "cycloheteroalkyl" as used herein refers to a 5-, 6- or 7-membered saturated ring which includes 1 or 2 hetero atoms such as nitrogen, oxygen and/or sulfur, such as



and the like.

The term "azacycloalkenyl" as used herein refers to a 4- to 8-membered ring such as



50 The term "amino acid side chain" refers to any of the known alpha-amino acids such as arginine, histidine, alanine, glycine, lysine, glutamine, leucine, valine, serine, homoserine, allothreonine, naphthylalanine, isoleucine, phenylalanine and the like.

The thrombin inhibitor compounds of formulae IV and IVA can be obtained as pharmaceutically acceptable acid addition salts by reacting the free base with an acid, such as hydrochloric, hydrobromic, fumaric, hydroiodic, nitric, sulfuric, phosphoric, acetic, citric, maleic, succinic, lactic, tartaric, gluconic, benzoic, methanesulfonic, ethanesulfonic, 2-hydroxyethanesulfonic, 1,2-ethanedisulfonic, benzenesulfonic, p-toluenesulfonic acid or the like.

55 The compounds of formulae IV and IVA are serine protease inhibitors, and in particular may inhibit thrombin, Factor Xa, and/or trypsin. The compounds of the present invention are useful for the treatment or prophylaxis of those processes which involve the production and/or action of thrombin. This includes a number of thrombotic and prothrombotic

states in which the coagulation cascade is activated which include, but are not limited to, deep vein thrombosis (DVT), disseminated intravascular coagulopathy (DIC), Kasabach-Merritt syndrome, pulmonary embolism, myocardial infarction, stroke, thromboembolic complications of surgery (such as hip replacement and endarterectomy) and peripheral arterial occlusion. In addition to its effects on the coagulation process, thrombin has been shown to activate a large number of cells (such as neutrophils, fibroblasts, endothelial cells, smooth muscle cells). Therefore, the above compounds may also be useful for the treatment or prophylaxis of adult respiratory distress syndrome, septic shock, septicemia, inflammatory responses which include, but are not limited to, edema, acute or chronic atherosclerosis, and reperfusion damage.

The above compounds may also be useful in treating neoplasia/metastasis (in particular those which utilize fibrin) and neurodegenerative diseases such as Alzheimer's disease and Parkinson's disease. In addition, the above compounds may be useful to prevent restenosis following arterial injury induced by endogenous (rupture of an atherosclerotic plaque) or exogenous (invasive cardiological procedure) events.

The above compounds may also be used as an anticoagulant in extracorporeal blood circuits, such as those necessary in dialysis and surgery (such as coronary artery bypass surgery).

The above compounds may also be used in combination with thrombolytic agents, such as tissue plasminogen activator (natural or recombinant), streptokinase, urokinase, prourokinase, anisolated streptokinase plasminogen activator complex (ASPAC), animal salivary gland plasminogen activators, and the like. The above compounds may act in a synergistic fashion to prevent reocclusion following a successful thrombolytic therapy and/or reduce the time to reperfusion. The above compounds may also allow for reduced doses of the thrombolytic agent to be used and therefore minimize potential hemorrhagic side-effects.

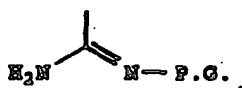
The above compounds may also be used in combination with other antithrombotic or anticoagulant drugs such as thromboxane receptor antagonists, prostacyclin mimetics, phosphodiesterase inhibitors, fibrinogen antagonists, and the like.

The above compounds that inhibit trypsin may also be useful for the treatment of pancreatitis.

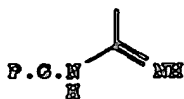
The above compounds of formula IV or IVA can be administered orally or parenterally to various mammalian species known to be subject to such maladies, e.g., humans, cats, dogs and the like in an effective amount within the dosage range of about 0.1 to about 100 mg/kg, preferably about 0.2 to about 50 mg/kg and more preferably about 0.5 to about 25 mg/kg (or from about 1 to about 2500 mg, preferably from about 5 to about 2000 mg) on a regimen in single or 2 to 4 divided daily doses.

The active substance can be utilized in a composition such as tablet, capsule, solution or suspension containing about 5 to about 500 mg per unit of dosage of active compound IV. They may be compounded in conventional matter with a physiologically acceptable vehicle or carrier, excipient, binder, preservative, stabilizer, flavor, etc., as called for by accepted pharmaceutical practice.

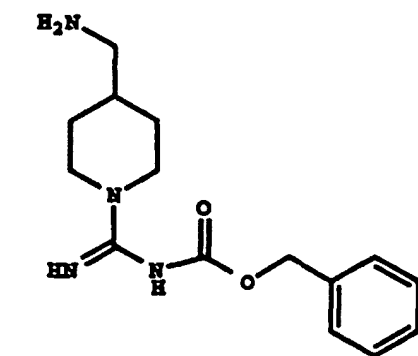
It will be appreciated that guanidine moiety



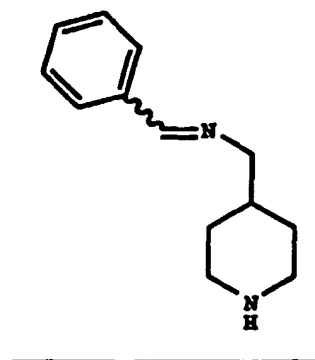
is used interchangeably with its tautomer



The following Examples represent preferred embodiments of the first embodiment of the present invention. Unless otherwise indicated, all temperatures are expressed in degrees Centigrade.

Example 1[[4-(Aminomethyl)-1-piperidiny]iminomethyl]carbamic acid, phenylmethyl ester

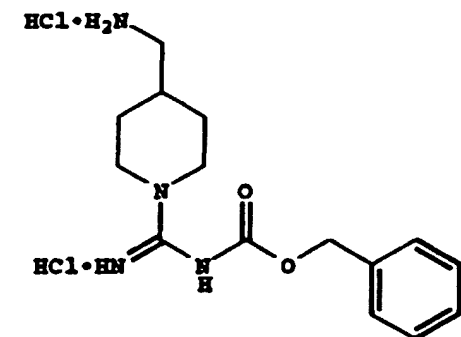
A.



35

A 500-mL, round-bottomed flask equipped with Dean-Stark trap was sequentially charged with 4-aminomethylpiperidine (14.84 g, 129.96 mmole), toluene (250 mL), and benzaldehyde (14.98 g, 141.16 mmole). The mixture was heated to reflux under an argon atmosphere and stirred overnight (18 h). The reaction was cooled to room temperature and the toluene was removed *in vacuo*. Residual toluene was removed under high vacuum to provide 28.14 g of the title compound as an orange oil (quantitative yield). The crude product was carried directly into the next step.

B.



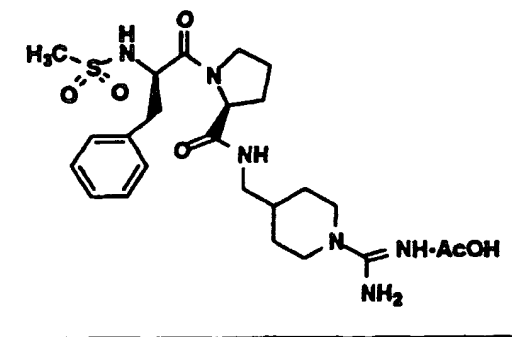
A 500-mL, round-bottomed flask was sequentially charged with Part A Schiff base (21.20 g, 104.8 mmole), acetonitrile (200 mL), [imino(1H-pyrazol-1-yl)methyl]carbamic acid, phenylmethyl ester (31.50 g, 128.96 mmole) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) (18 mL, 120.36 mmole). After stirring for five minutes, the solution became clear yellow. The reaction was heated to 50°C and stirred under a nitrogen atmosphere for 16 h. After the reaction had cooled to room temperature, 12N hydrochloric acid (36 mL, 432 mmole, reaction mixture reached pH 1) was added over 20 minutes. The reaction was stirred for 2.5 h at room temperature. The mixture was concentrated *in vacuo* to a yellow oil and isopropanol (35 mL) was added. With stirring, acetonitrile (250 mL) was added resulting in the separation of an oil. The mixture was heated to 40 °C providing a clear solution which was seeded. Within five minutes a white solid crystallized from solution. The slurry was stirred for an additional 40 minutes at 40°C and then cooled to room temperature and stirred overnight. The product was collected by filtration and washed with 1:1 ethyl acetate/hexane (1 X 100 mL), 1:3 ethyl acetate/hexane (1 X 100 mL), and hexane (3 X 100 mL). Residual solvents were removed under high vacuum to provide 29.95 g of an 11:1 mixture of title compound:4-aminomethyl piperidine, dihydrochloride salt as a white solid (79%).

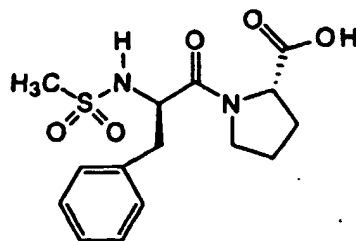
C. [[4-(Aminomethyl)-L-piperidiny]iminomethyl]carbamic acid, phenylmethyl ester

Sodium hydroxide (4.45 g, 111.25 mmole) was dissolved in 150 mL of deionized water. A mixture of Part B compound and the 4-aminomethyl piperidine, dihydrochloride salt (prepared in Part B, 16.18 g, 44.54 mmole) was added (pH of the cloudy solution was 13) and the mixture was extracted with dichloromethane (1 X 200 mL and 2 X 100 mL). The organic layers were combined and washed with brine (1 X 200 mL), dried (MgSO<sub>4</sub>), filtered and concentrated *in vacuo* to provide the title compound as a white foam (12.29 g, 95%).

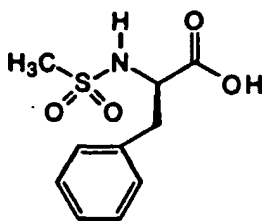
Example 2

N-[[[(1-Aminoiminomethyl)-4-piperidiny]methyl]-L-[N-(methylsulfonyl)-D-phenylalanyl]-L-prolinamide, acetate (1:1)



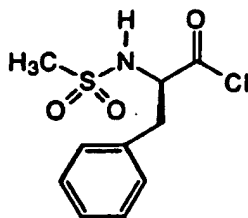
A. [N-(Methylsulfonyl)-D-phenylalanyl]-L-proline

A(1).



D-Phenylalanine (15.01 g, 90.865 mmol) was weighed into a 250-mL, 5-necked, round-bottomed flask equipped with thermocouple, pH probe, overhead stirrer and two addition funnels (one a constant-rate funnel to ensure even addition of methanesulfonyl chloride). Sodium hydroxide (3.642 g, 91.05 mmol) was dissolved in 90 mL of deionized water and added to the reaction flask. With stirring, the mixture became a clear solution. The internal temperature was brought to -2 °C (pH 12.3). With rapid stirring, methanesulfonyl chloride (5.0 mL, 64.60 mmol) was added via the constant-rate addition funnel. Once pH 11 was reached, 6N NaOH was added dropwise to maintain the pH at  $10.9 \pm 0.2$ . A second portion of methanesulfonyl chloride (4.2 mL, 54.26 mmol) was then added while maintaining the pH at  $10.5 \pm 0.2$  (internal temperature  $<8^\circ$ ) by dropwise addition of 6 N sodium hydroxide. Once the pH had stabilized at 10.5, HPLC analysis of an aliquot showed a 9:1 mixture of the title compound to D-phenylalanine. A third portion of methanesulfonyl chloride (1.2 mL, 15.5 mmol) was then added at  $0^\circ$  over 5 minutes while maintaining the pH at  $10.5 \pm 0.2$ . After the addition was complete and the pH had stabilized at 10.4, the reaction mixture was brought to pH 13 with 6N sodium hydroxide, allowed to warm to 15 °C over 2 hr, and then washed with methyl isobutylketone (2 X 100 mL). The aqueous layer was acidified to pH 1 with 6N hydrochloric acid and extracted with ethyl acetate (1 X 200 mL and 2 X 150 mL). The ethyl acetate layers were combined and washed with brine (1 X 150 mL), dried over  $\text{MgSO}_4$ , and concentrated *in vacuo* to yield a yellow oil (18.36 g, 83%). HPLC analysis of the oil showed a 7:1 mixture of the title compound to [N-methylsulfonyl-D-phenylalanine]-D-phenylalanine. This material was carried into the next step without further purification.

A(2).



The Part A(1) mixture of N-methylsulfonyl-D-phenylalanine and [N-methylsulfonyl-D-phenylalanine]-D-phenyla-



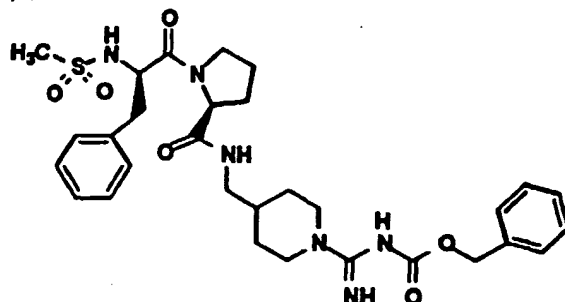
lanine (18.36 g, 75.47 mmol) was dissolved in 250 mL of dichloromethane under an argon atmosphere. Heating to reflux and stirring for about 15 minutes was necessary to completely dissolve the material. After the solution had cooled to room temperature, DMF (0.23 mL, 2.97 mmol) was added and the internal temperature was further lowered to 3 °C (ice bath). Oxalyl chloride (7.4 mL, 84.85 mmol) was added in a steady stream over 2 minutes. After the addition was complete, the reaction was allowed to warm to room temperature over 3 hours and then stirred at room temperature for one hour. The mixture was concentrated *in vacuo* to a yellow oil, toluene (100 mL) was added and the solution was concentrated to a yellow oily solid (19.89 g, 101%). This material was stored in a refrigerator overnight under an argon atmosphere and was carried into the next step without further purification.

A(3). [N-(Methylsulfonyl)-D-phenylalanyl]-L-proline

The crude Part A(2) acid chloride prepared above was dissolved in 120 mL of toluene, with heating to 40°C, and then cooled to room temperature under an argon atmosphere. L-proline (13.11 g, 113.87 mmol) was weighed into a 500-mL, 5-necked flask equipped with two addition funnels, thermocouple, pH probe and overhead stirrer. Sodium hydroxide (2.68 g, 67 mmol) was dissolved in 120 mL of deionized water and added to the reaction flask. The proline readily dissolved with stirring to give a clear solution which was cooled to 0°C. The initial pH was 12.15. The acid chloride-toluene solution was added dropwise to the rapidly stirring proline solution until the pH reached 11.0 (internal temperature maintained at <5°C). The remainder of the acid chloride was added dropwise over 25 minutes while maintaining the internal temperature below 5°C and the pH at 11.0 ± 0.2 by dropwise addition of 4N sodium hydroxide (23 mL total). The acid chloride was washed in with 20 mL of toluene. After the addition was complete and the pH had stabilized to 11.1, the icebath was removed and the reaction was allowed to warm to 12°C over 30 minutes. The aqueous and organic layers were separated and the basic aqueous layer was washed with ethyl acetate (1 X 100 mL, discard). Ethyl acetate (350 mL) was added to the basic aqueous solution and while stirring vigorously, the mixture was acidified with 6N hydrochloric acid to pH 1. The organic and aqueous layers were separated and the acidic aqueous was extracted with ethyl acetate (2 X 150 mL). The combined ethyl acetate layers from the acidic extractions were washed with brine (1 X 150 mL), dried (MgSO<sub>4</sub>), filtered, and concentrated *in vacuo* to a total weight of 260 g, providing a slurry of the title compound in the ethyl acetate. With stirring, 260 mL of hexane was added and the slurry was stirred for 4 h at room temperature. The white crystalline solid was collected by filtration, washed with hexane/ethyl acetate (2:1, 2 X 100 mL) followed by hexane (2 X 100 mL). Drying *in vacuo* provided the title compound (20.84 g, 84%) as a white crystalline solid.

B. N-[[1-(Aminoiminomethyl)-4-piperidiny]methyl]-L-[N-(methylsulfonyl)-D-phenylalanyl]-L-prolinamide, acetate (1:1)

B (1) .



A 500-mL, round-bottomed flask was sequentially charged with Example 1 compound (10.41 g, 35.84 mmole), isopropanol (60 mL), deionized water (60 mL), and Part A compound (10.00 g, 29.38 mmole). Under an argon atmosphere, the clear yellow solution was brought to 10°C and 1-hydroxybenzotriazole hydrate (4.40 g, 32.56 mole) was added. The mixture was further cooled to 4°C and 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (6.53 g, 34.06 mole) was added. The resulting clear solution was stirred between 1 and 4°C for 3 hours and then slowly warmed to 20°C over 14 hours. A portion of the solvent (62 g) was removed *in vacuo*. Ethyl acetate (250 mL) was added. With stirring, deionized water (465 mL) and 6N hydrochloric acid (40 mL) were added. The aqueous and organic

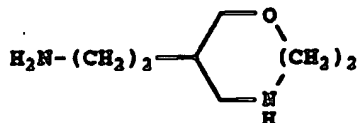
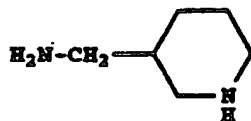
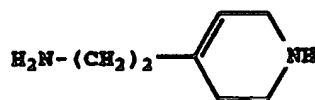
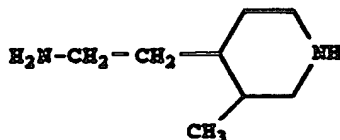
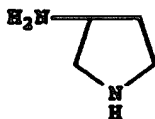
layers were separated and the aqueous layer was washed with ethyl acetate (1 X 100 mL). The combined ethyl acetate layers were concentrated to 100 g and extracted with 0.5N hydrochloric acid (2 X 60 mL). The combined acidic aqueous layers were brought to pH 6 with 12N sodium hydroxide and extracted with dichloromethane (1 X 250 mL and 2 X 150 mL). The dichloromethane layers were combined and washed with deionized water (1 X 150 mL) and brine (1 X 150 mL), dried ( $\text{MgSO}_4$ ), filtered and concentrated *in vacuo*. The residual solvents were removed under high vacuum to provide title CBZ-protected compound as a white foam (15.44 g, 83% yield, corrected for ethyl acetate in  $^1\text{H}$  NMR). The crude product was carried directly into the next step.

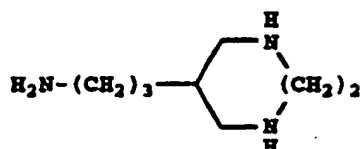
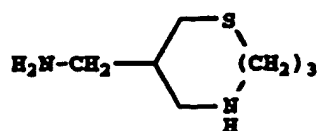
**B(2). N-[1-(Aminoiminomethyl)-4-piperidiny]methyl]-1-[N-(methylsulfonyl)-D-phenylalanyl]-L-prolinamide, acetate (1:1)**

A solution of Part B(1) CBZ-protected compound (13.22 g, 21.58 mole) in MeOH (150 mL) was purged with argon for ten minutes. Palladium hydroxide on carbon (1.32 g) was added and the mixture was again purged with argon for ten minutes. The solution was then purged with hydrogen and the reaction was stirred under a hydrogen atmosphere for 2.5 hours. After the reaction was complete by HPLC, the mixture was purged with argon, filtered through celite and the celite washed with methanol (2 X 100 mL). Acetic acid was added and the solution was concentrated *in vacuo* to an oil. Isopropanol (100 mL) was added and the solution concentrated *in vacuo* to 45 g. The thick solution was seeded. With stirring, 180 mL of acetonitrile was added over 20 minutes. Within three hours, a white solid crystallized from solution and the resulting slurry was allowed to stir overnight at room temperature. The solid was collected by filtration and washed with acetonitrile (1 X 50 mL), 1:1 hexane/ethyl acetate (1 X 60 mL), and hexane (2 X 50 mL). The product was dried *in vacuo* to yield the title compound as a white crystalline solid (8.83 g, 76%).

Following the procedure of Example 1 Part A, except substituting for 4-aminomethylpiperidine, the compound set out below in Table A, the corresponding protected compound III is formed which is reacted with protected guanylpurazole II to form intermediate I following the procedure as described in Example 1.

**Table A**

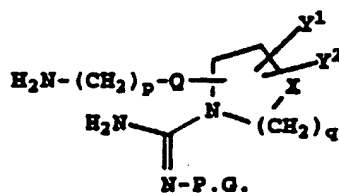




Following the procedure of Example 2, except employing the intermediate formed from Table A amine, the corresponding thrombin inhibitor IV is formed.

## 20 Claims

- 1. A process for preparing a guanidine compound of the structure**



wherein p is 0, 1 or 2;  
Q is a single bond or



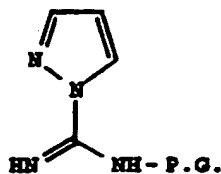
**Y<sup>1</sup> and Y<sup>2</sup> are independently H, lower alkyl or halo;**

X is CH<sub>2</sub>, -CH=CH-, O, S or NH;

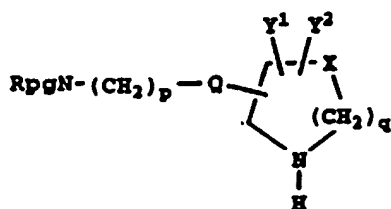
q is 0, 1, 2, 3 or 4 if X is CH<sub>2</sub> or -CH=CH-;

q is 2, 3 or 4 if X is O, S or NH;

and P.G. is an amine protecting group, which comprises providing a protected guanylpurazole of the structure

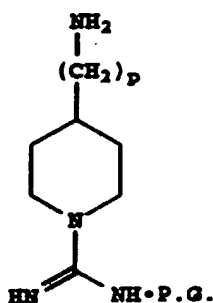


where P.G. is as defined above, and reacting the protected guanylpurazole with a heterocyclic compound of the structure

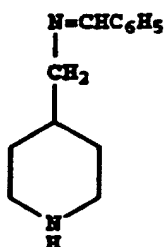


where p, Q, X, q and Y<sup>1</sup> and Y<sup>2</sup> are as defined above and Rpg is an N-protecting group, in the presence of a basic catalyst, to form the guanidine intermediate.

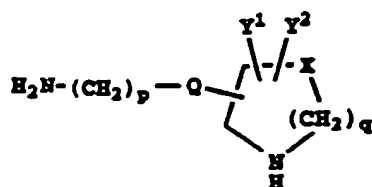
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2. The process as defined in Claim 1 wherein the basic catalyst is 1,8-diazabicyclo[5.4.0]undec-7-ene.
  3. The process as defined in Claim 1 or 2 wherein the protected guanylpurazole is employed in a molar ratio to the heterocyclic compound within the range from about 1:1 to about 3:1.
  - 20 4. The process as defined in Claim 1, 2 or 3 wherein the reaction is carried out at a temperature within the range from about 20 to about 70°C.
  5. The process as defined in Claim 1, 2, 3 or 4 wherein the Rpg N-protecting group is =CHC<sub>6</sub>H<sub>5</sub>, benzyloxycarbonyl (CBZ) or t-butoxycarbonyl (BOC).
  - 25 6. The process as defined in any one of Claims 1-5 wherein Q is a single bond, Y<sup>1</sup> and Y<sup>2</sup> are each H, X is CH<sub>2</sub>, q is 1 or 2.
  7. The process as defined in any one of Claims 1-5 wherein the guanidine compound prepared is
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8. The process as defined in Claim 7 wherein the heterocyclic compound is

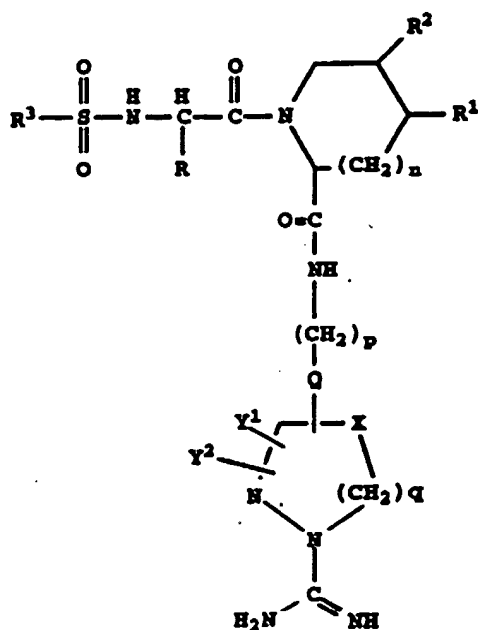


9. The process as defined in any preceding claim wherein the heterocyclic compound starting material is prepared by reacting an unprotected amino compound of the structure



with an aldehyde at a temperature within the range from about 20 to about 120°C.

10. A process for preparing a sulfonamido heterocyclic thrombin inhibitor of the structure



wherein R is hydrogen, hydroxyalkyl, aminoalkyl, amidoalkyl, alkyl, cycloalkyl, aryl, arylalkyl, alkenyl, alkynyl, arylalkoxyalkyl, or an amino acid side chain, either protected or unprotected;

R<sup>1</sup> and R<sup>2</sup> are independently hydrogen, lower alkyl, cycloalkyl, aryl, hydroxy, alkoxy, oxo (also referred to as keto), thioxo, thioketal, thioalkyl, thioaryl, amino or alkylamino; or R<sup>1</sup> and R<sup>2</sup> together with the carbons to which they are attached form a cycloalkyl, aryl, or heteroaryl ring; and

R<sup>3</sup> is lower alkyl, aryl, arylalkyl, heteroaryl, quinoliny or tetrahydroquinoliny;

n is 0, 1 or 2;

Y<sup>1</sup> and Y<sup>2</sup> are independently H, lower alkyl or halo;

p is 0, 1 or 2;

Q is a single bond or



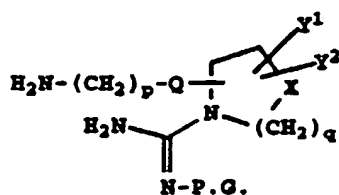
X is CH<sub>2</sub>,-CH=CH-, O, S or NH;

q is 0, 1, 2, 3 or 4 if X is CH<sub>2</sub>, or -CH=CH-;

q is 2, 3 or 4 if X is O, S or NH;

provided that where X is a hetero atom, then there must be at least a 2-carbon chain between X and any N atom in the ring or outside the ring;

which process comprises providing a guanidine intermediate of the structure



wherein p is 0, 1 or 2;

Q is a single bond or



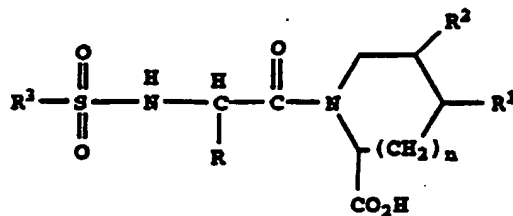
Y<sup>1</sup> and Y<sup>2</sup> are independently H, lower alkyl or halo;

X is CH<sub>2</sub>, -CH=CH-, O, S or NH;

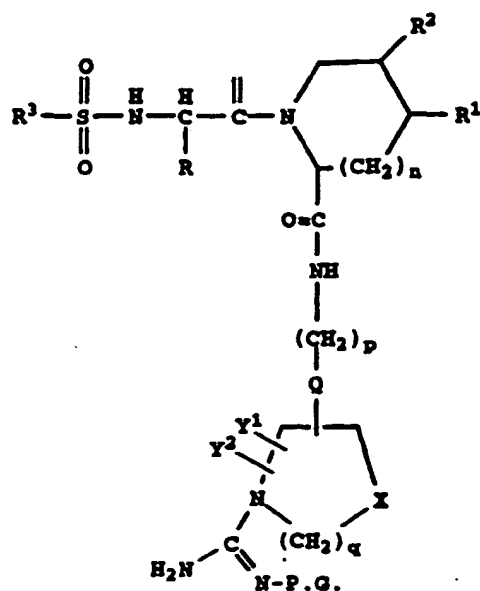
q is 0, 1, 2, 3 or 4 if X is CH<sub>2</sub> or -CH=CH-;

q is 2, 3 or 4 if X is O, S or NH;

and P.G. is a protecting group which is benzyloxycarbonyl (CBZ) or t-butoxycarbonyl (BOC), reacting the guanidine intermediate with an amino acid of the structure



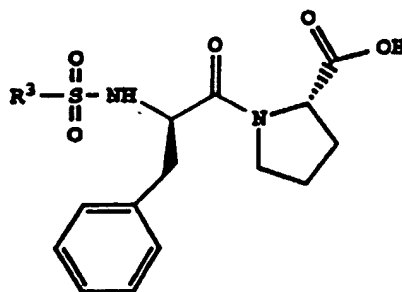
in a carbodiimide coupling reaction in the presence of a coupling agent and a base to form the protected amide compound



and treating the protected amide compound with a deprotection agent to form the guanidine thrombin inhibitor.

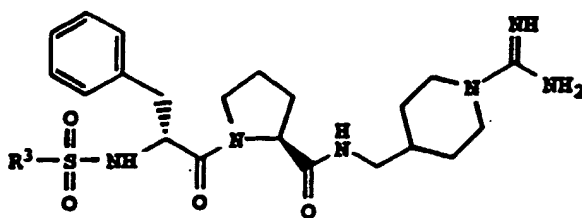
11. The process as defined in Claim 10 wherein the coupling reaction is carried out in the presence of ethyl 3-(3-dimethylamino)propyl carbodiimide hydrochloride, dicyclohexylcarbodiimide or diisopropylcarbodiimide; and 1-hydroxybenzotriazole monohydrate, and optionally in the presence of a base which is N-methyl morpholine or triethylamine.

12. The process as defined in Claim 10 or 11 wherein the starting acid compound has the structure



wherein R³ is alkyl, aryl, or arylalkyl.

13. The process as defined in Claim 12 wherein the guanidine thrombin inhibitor as formed has the structure



where R³ is preferably CH₃ or benzyl.

14. The process as defined in Claim 10, 11 or 12 wherein the guanidine intermediate is employed in a molar ratio to the acid compound within the range from about 1:1 to about 3:1.
- 5 15. The process as defined in any one of Claims 10-14 wherein the coupling reaction is carried out at a temperature within the range from about 0 to about 30°C.
16. The process as defined in any one of Claims 10-15, wherein the guanidine intermediate is prepared by the process as defined in any one of Claims 1-9.

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European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 96 30 7111

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	WO 94 29336 A (ASTRA AB ;ANTONSSON KARL THOMAS (SE); BYLUND RUTH ELVY (SE); GUSTA) 22 December 1994 see formula 1, page 5; pages 41-43; pag 52; examples on pages 66-75 ---	1-16	C07D211/26 C07D207/14 C07D211/70 C07D267/10 C07D281/18 C07D243/10 C07K5/06
Y	US 5 498 724 A (NYSTROEM JAN-ERIK ET AL) 12 March 1996 see column 2, lines 20-56 ---	1-9,16	
Y	EP 0 559 046 A (HOFFMANN LA ROCHE) 8 September 1993 see page 6, compound III ---	1-16	
D,Y	EP 0 601 459 A (SQUIBB BRISTOL MYERS CO) 15 June 1994 * the whole document * -----	1-16	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			C07D C07K
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 18 February 1997	Examiner Steendijk, M
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- &amp; : member of the same patent family, corresponding document</p>			

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